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Report DRXTH-FS-TR-81105

SURVEY OF HAZARDOUS/CHEMICAL AREA NO. 2 OF THE FORMER ST. LOUIS ORDNANCE PLANT

VOLUME I

William R. Colvin
Joseph H. Zarzycki

June 1981

Final Report

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US Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, MD 21010

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Hazardous/Chemical Area No. 2 of the former St. Louis Ordnance Plant (SLOP) was surveyed for explosive and heavy metal contamination. A portion of this area was occupied as the Goodfellow US Army Reserve Center (GUSARC) from 1960-1977 and used for Army Reserve operations and training; the remaining portion was utilized by Hanley Industries, Inc. from 1959-1979 for the manufacturing of explosive and pyrotechnic devices. The Department of Labor (DOL) desires both the GUSARC and the Hanley Areas for the site of a Job Corps Center. The DOLhad need for the earliest possible use of the GUSARC Area. (over)

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Therefore, the USATHAMA survey of Hazardous/Chemical Area No. 2 was conducted in two phases: Phase I was the survey of the GUSARC and Phase II was the survey of the Hanley Area.

The findings of the GUSARC Area survey (conducted January - May 1979) revealed the presence of heavy metal residues on the interior surfaces of buildings as well as the presence of explosive residues in the floor drains of four buildings. This information was transmitted to DOL in June 1979 to provide guidance for their renovation and demolition activities in the GUSARC Area.

The findings of the Hanley Area survey (conducted August-November 1980) showed heavy metal residues to be present on the interior surfaces of all buildings and in the aqueous discharge of the sewer system. Additionally, explosive residues were found on the interiors of several buildings and magazines and in the water of several powder wells draining two buildings. It is recommended that four buildings, eight magazines and all powder wells be decontaminated to remove the potential explosive hazard.

EXECUTIVE SUMMARY

The Hazardous/Chemical Area No. 2 of the former St. Louis Ordnance Plant (SLOP) was surveyed for explosive and heavy metal contamination. A portion of this area was occupied as the Goodfellow US Army Reserve Center (GUSARC) from 1960-1977 and used for Army Reserve operations and training; the remaining portion was utilized by Hanley Industries, Inc. from 1959-1979 for the manufacturing of explosive and pyrotechnic devices. The Department of Labor (DOL) desires both the GUSARC and the Hanley Areas for the site of a Job Corps Center. The DOL had need for the earliest possible use of the GUSARC Area. Therefore, the USATHAMA survey of Hazardous/Chemical Area No. 2 was conducted in two phases: Phase I was the survey of the GUSARC and Phase II was the survey of the Hanley Area.

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I. INTRODUCTION.

Hazardous/Chemical Area No. 2 (27.88 acres) of the former St. Louis Ordnance Plant (SLOP) is desired by Department of Labor (DOL) for use as a Job Corps Training Center. This property is considered excess to Army needs. The US Army Toxic and Hazardous Materials Agency (USATHAMA) was requested to study the property with respect to ascertaining the "status of contamination" and to determine the suitability of the property for release.

The USATHAMA program was conducted in two phases due to DOL schedule considerations and the requirements of an Army lease with Hanley Industries. Each phase consisted of three steps: historical review of property usage, survey consisting of sampling and chemical analysis, and data evaluation. During the period January through May 1979, a 13.2 acre portion of the property, referred to as the Goodfellow US Army Reserve Center (GUSARC) Area, was surveyed. The remaining 14.68 acres, referred to as the Hanley Area, were surveyed during the period August-November 1980.

The following sections of this document describe the results obtained and information gathered by USATHAMA during its study of the Hazardous/Chemical Area No. 2. Section II and Appendix A provide the authority for the program. Section III presents an overview of the technical program conducted by USATHAMA. Section IV provides background information, primarily of a historical nature. The historical information in this section is extracted from an archives search which USATHAMA conducted; the complete archives search is at appendix B. Sections V and VI are descriptions of the sampling and analysis efforts conducted at the GUSARC and Hanley Areas, respectively. All analytical results as well as laboratory quality control data and method descriptions for the analytical program are contained in appendices D, E, and F. Conclusions and recommendations are found in sections VII and VIII, respectively. This report has been prepared in two volumes; volume II contains appendices A through F.

II. AUTHORITY. Authority for conducting this survey of the SLOP is contained in:

A. 1st Indorsement, DRCIS-EP, DARCOM, to HQDA letter (December 18, 1980) dated January 17, 1979, subject: Installation Restoration, Goodfellow US Army Reserve Center (Portion of Former St. Louis Ordnance Plant), Missouri. (Document contained at appendix A).

B. DARCOM Regulation 10-30, May 22, 1979 which establishes the US Army Toxic and Hazardous Materials Agency and its mission.

C. Federal Register Vol. 45, No. 209, Oct 27, 1980 Amendments to Real Estate Handbook, Subpart F - Disposal.

III. BACKGROUND.

A. General. SLOP is located within the city limits of St. Louis, Missouri (Fig 1). The area surrounding SLOP is commercial, residential and industrial. The USATHAMA program addresses only the 27.88 acres comprising Hazardous/Chemical Area No. 2 of the former ordnance plant.

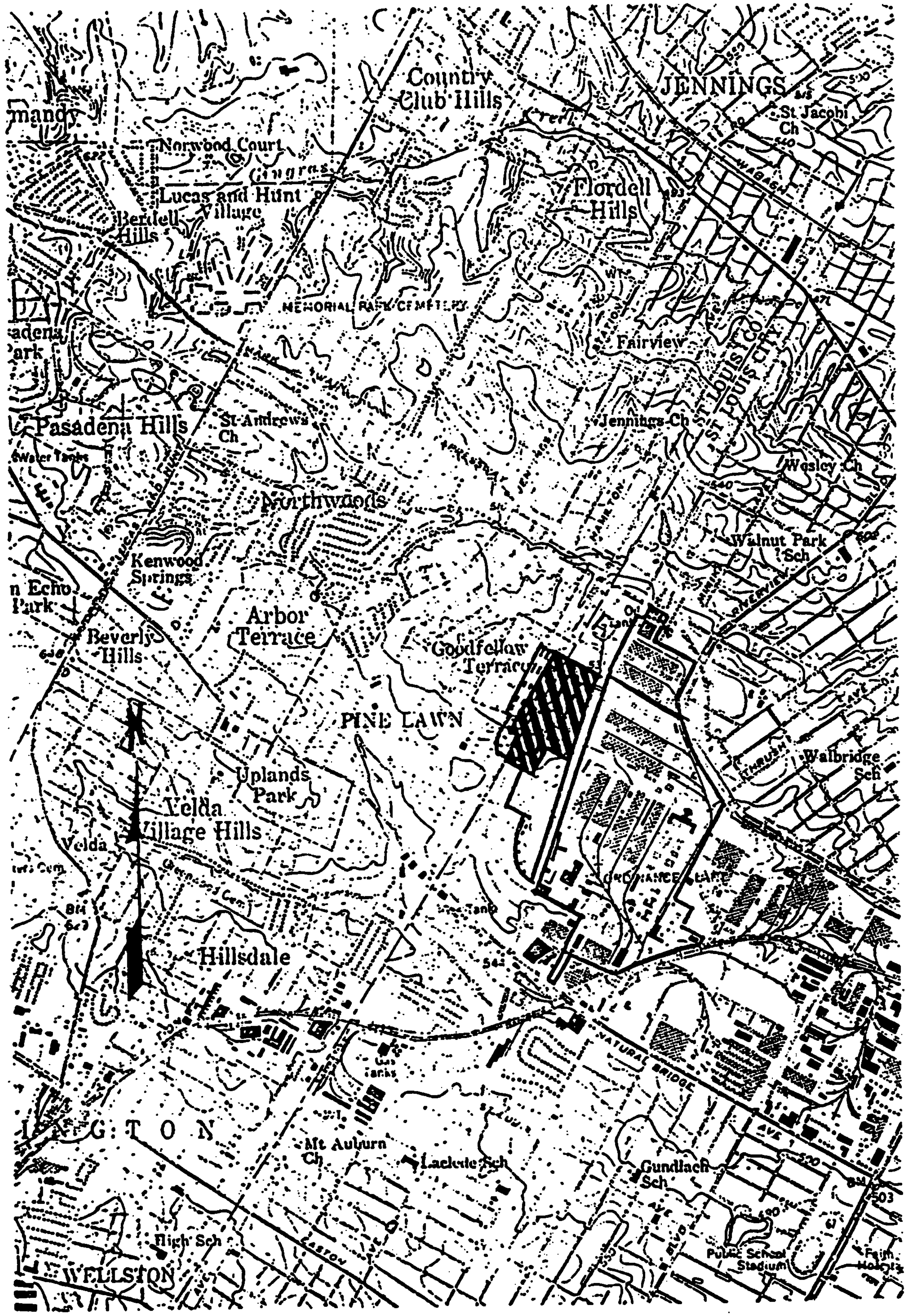

Figure 1. St. Louis Ordance Plant and vicinity depicting Hazardous/Chemical Area No. 2.

B. History.

1. St. Louis Ordnance Plant Overall Plant Operations

a. 1941-1959

(1) General: Construction was started during January 1941 and was completed in May 1942. Initial production, however, started as early as December 1941. During World War II, the 300-acre facility was operated as a Government-owned, contractor-operated (GOCO) plant for the production of small arms ammunition (caliber .30 and .50) and components for the 105mm shells.

(2) Major Contractor Operators:

(a) The United States Cartridge Company (U. S. Cartridge), a subsidiary of Olin Industries, operated the ammunition plant for manufacture of small arms ammunition and produced 67 million rounds. U. S. Cartridge occupied plants No. 1 and 2 (Fig 2). Plant No. 1 comprised buildings in the 100 series and plant No. 2, buildings in the 200 series.

(b) The McQuay-Norris Manufacturing Company operated the plant for manufacture of cores for small arms ammunition and produced eight billion cores. McQuay-Norris occupied the 113 building series on the extreme south end, located south of highway 70 on Goodfellow Blvd. near Natural Bridge Road.

(c) The Chevrolet-Shell Division of the General Motors Corporation operated the shell plant for the manufacture of 105mm shells. The facility began production late in 1945 following the change over from small arms ammunition manufacturing. The number of shells produced is unknown.

Following deactivation of the plant in 1945, all property and buildings except the McQuay-Norris plant were transferred to the Seventh Service Command for use as an administrative center for the Army Service Forces.

b. 1945-1959. From 1945 to 1951 the plant was utilized as a center for maintaining and servicing records of the U. S. Army Adjutant General's Office and the Finance Center. During this period the plant was administered by the St. Louis Administration Center under the jurisdiction of the Fifth Army Region. On May 1, 1952 the St. Louis Administration Center was discontinued and its function transferred to SLOP. These functions consisted of Army housekeeping services to Army Finance Center. Effective 1 December 1957 the SLOP was placed in an inactive status.

2. Hazardous/Chemical Area No. 2, 1941-1945

a. General. According to information provided by a former employee, magnesium was used in buildings 223A and B for tracer bullet manufacture. In building 234, on the extreme south end, lead styphnate and possibly tetrazene were used in the manufacture of primers and several buildings were used for explosive mixing and storage.

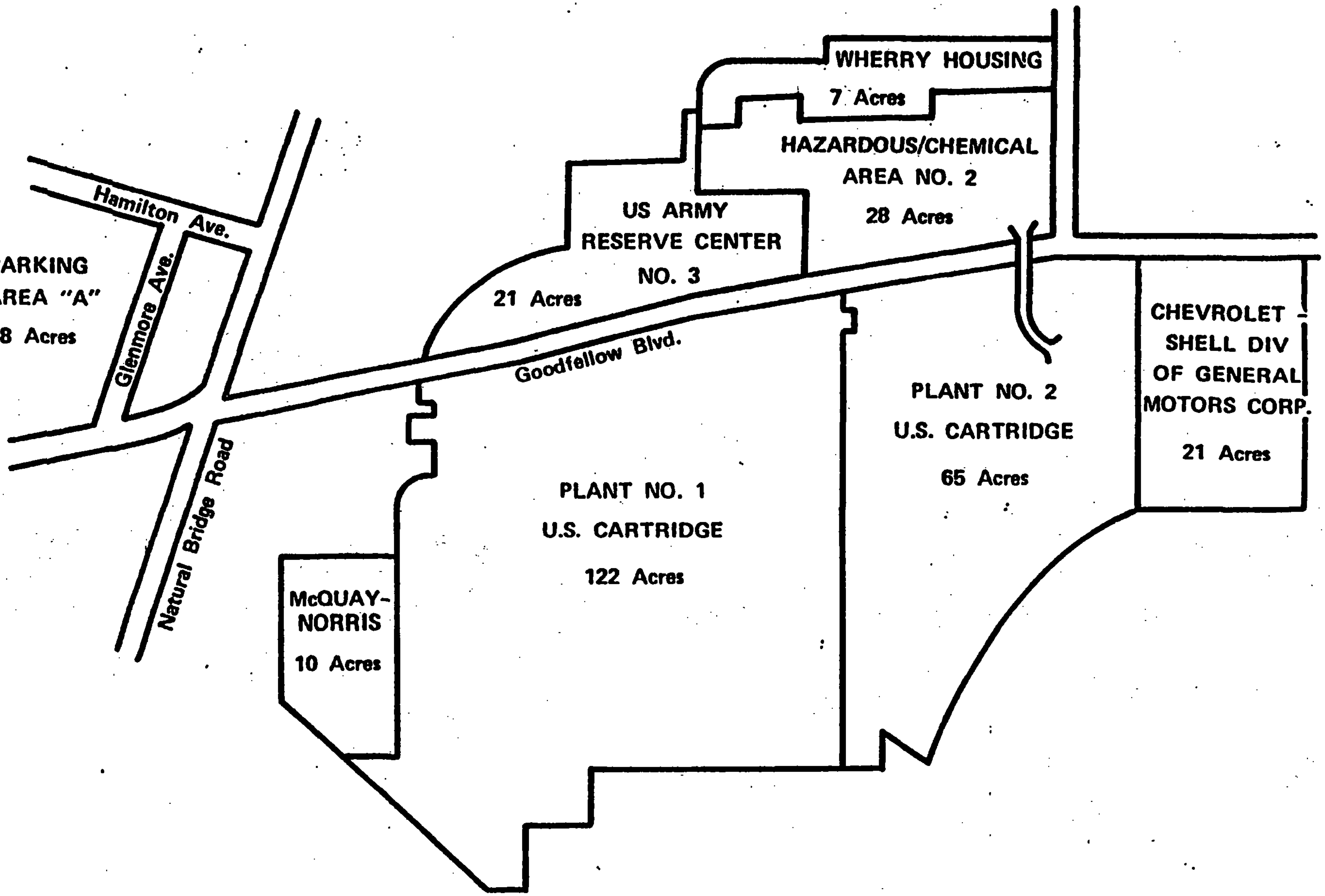

Figure 2. Outlease map of St. Louis Ordance Plant.

b. Decontamination. In 1945, following deactivation of SLOP, buildings having explosive contamination were decontaminated by the Army COE reportedly in accordance with regulations of the Safety and Security Branch, Office, Chief of Ordnance, Chicago. However, no records are available which describe the procedures employed or the results obtained in the decontamination project. All special equipment peculiar to the production of small arms ammunition was declared excess and recommended for scrapping. All multi-purpose equipment was made available to the Reconstruction Finance Corporation for disposition.

3. Hazardous/Chemical Area No. 2, 1945-1959. As buildings were made available, the US Army Finance Center used them for classrooms until 1951. At that time the area was rehabilitated for small arms ammunition manufacture. The machinery was installed but production never commenced. After the Korean Conflict, the machinery was removed and disposed of.

4. Hazardous/Chemical Area No. 2, 1959-1979.

a. General. Hanley Industries, Inc. (a subsidiary of KDI Precision Products) leased 14.68 acres of Hazardous/Chemical Area No. 2 of SLOP from September 1, 1959 to August 31, 1979. In the early 1960's, the Goodfellow US Army Reserve Center (GUSARC) was established on the remaining 13 acres of Hazardous/Chemical Area No. 2 (Fig. 3). Shown on Figure 4 are the building/magazine/bunker numbers for the structures in both the GUSARC and Hanley Areas.

b. Hanley Industries, Inc. (Hanley) Operations.

(1) Manufacturing Operations

Hanley operated equipment normally required for the synthesis receiving, drying, screening, mixing, loading, pressing and testing of explosives. Hanley did considerable work in the design of explosive trains and components (Table 1). Additionally explosive components were loaded for the military, and the National Aeronautical and Space Administration (NASA) (Table 2).

Most of Hanley's buildings were used for loading detonators and primers and for explosive mixing (Table 3). Explosives were dried in magazines 219C, B, F, J and H by leaving cans of explosives (without lids) exposed to the air.

Hanley operated a lead azide reactor in magazine 219E. Feed tanks were located just outside the concrete wall. Two feed lines for the conveyance of sodium azide and lead nitrate ran via overhead supports from the tanks to the reactor (two pumps were used). The tanks, feed lines and reactor have been removed. Table 4 lists the buildings usage during Hanley's lease.

A list of compounds which Hanley used is shown on Table 5.

(2) Disposal Operations.

Hanley used none of the existing sumps or powder wells located on the property. Paper and cloths contaminated with explosives were burned in the basement of 218C. Open burning of explosives was also conducted in magazines 219F and J. All other explosives wastes were transported to Fort Leonard Wood for disposal.

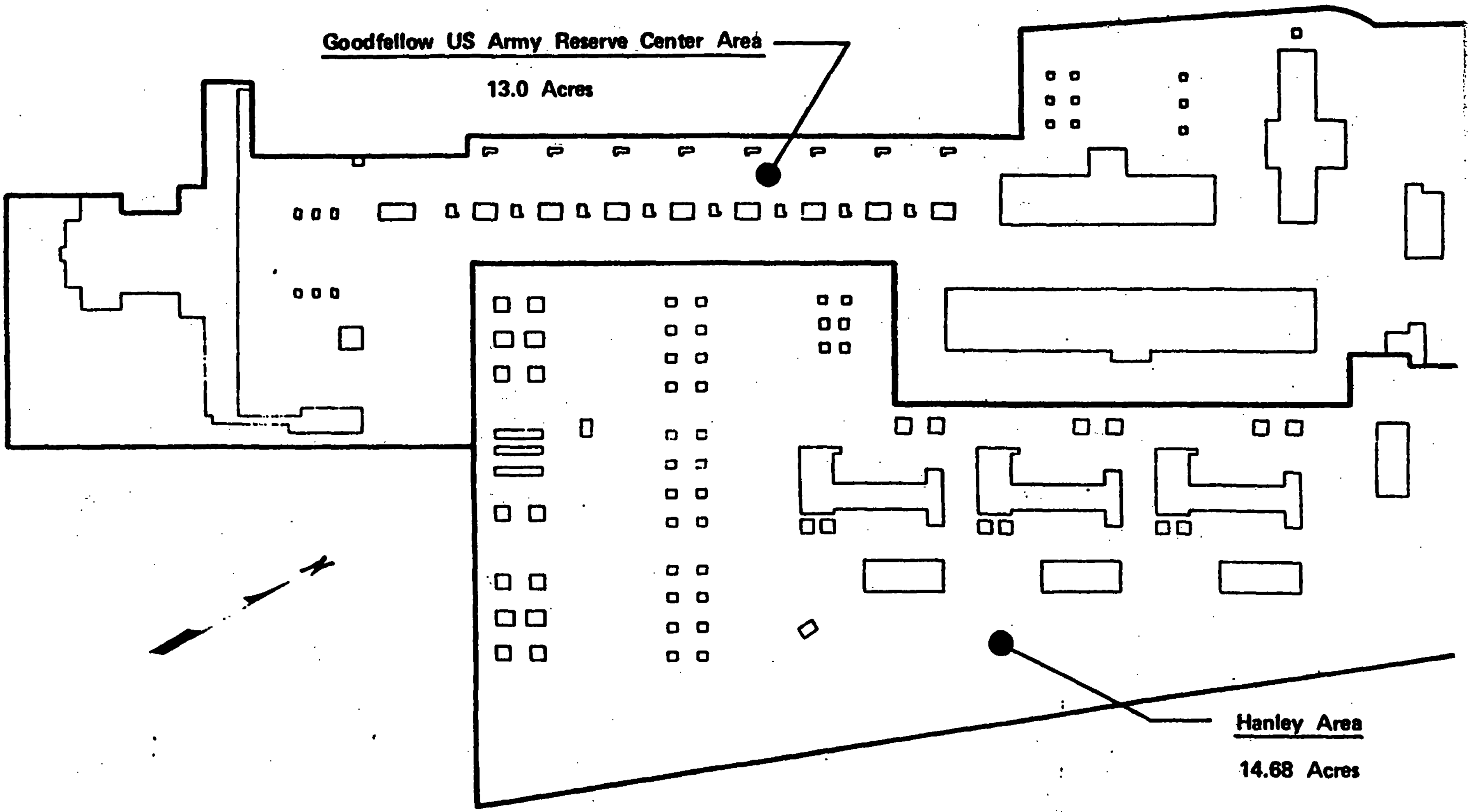

Figure 3. Hanley and Goodfellow US Army Reserve Center Areas of Former Hazardous/chemical Area No. 2 of SLOP.

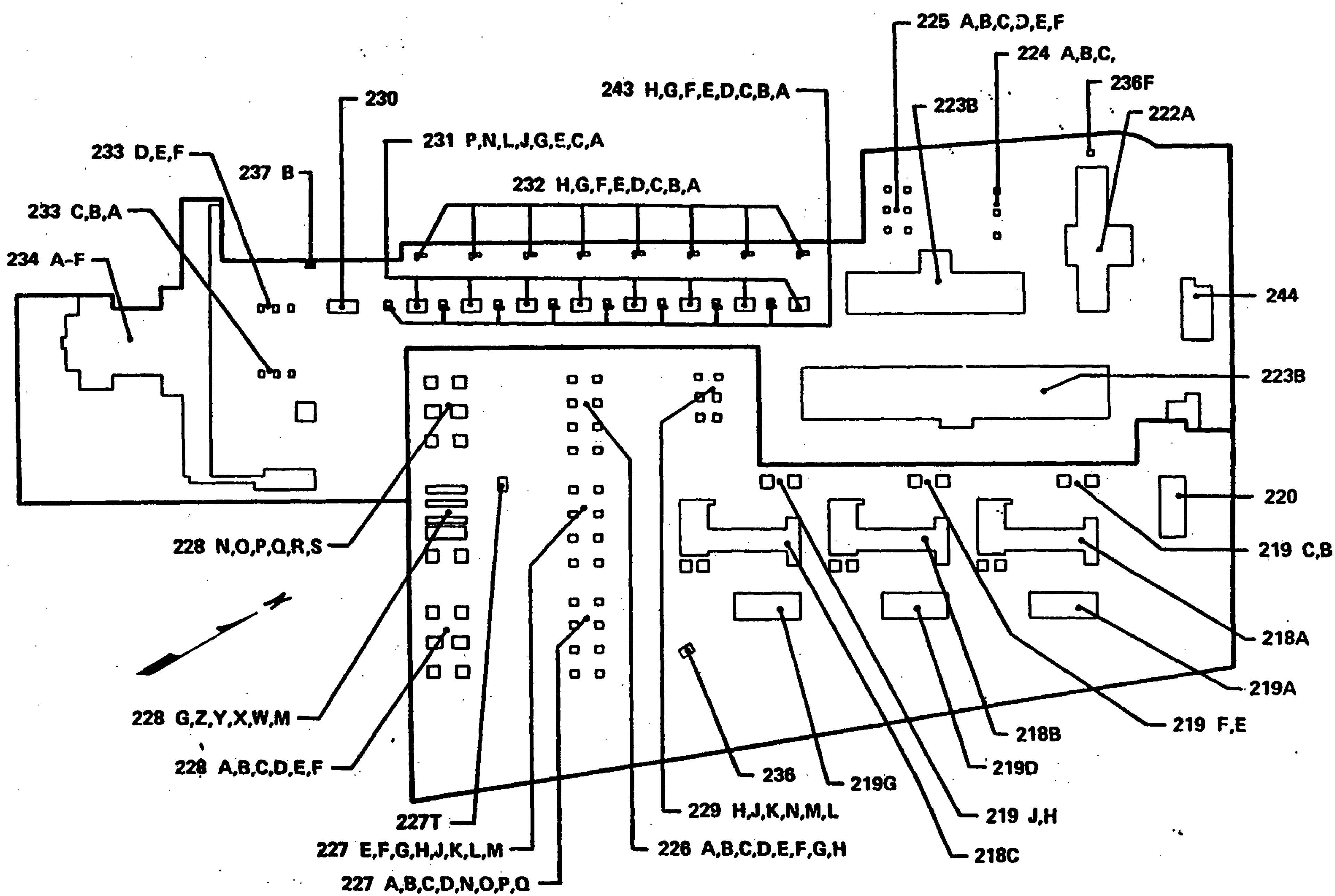

Figure 4. Building/Magazine Numbers – Hazardous/Chemical Area No. 2 of SLOP.

TABLE 1

Hanley Industries

Explosive Trains and Components Designed

Explosive bolts

Cord cutters

Bolt cutters

Battery activiation cartridges

Cartridges to spin up a gyroscope

Balloon inflaters

Bellows and piston motors

Pellets of explosives

Bailer tube expansion charges

Unusual primary explosives

Spotting charges for warheads

Explosive detents

Indicators

Smoke and flash signals

Explosive or squib switches

Cartridges to uncage a gyroscope

Boosters

Pyrotechnic delay cartridges and detonators to open lap belts

Deploy parachutes

High altitude sounding grenades

TABLE 2

Hanley Industries

Explosive Components Loaded for the Military and NASA

Delay cartridges
Leads
Detonators
Primers (electric and delay)
Squibs
Explosive Bolts
Activators
Bomb Initiators
Spotting charges
Boosters

TABLE 3

Hanley Industries

Buildings/Magazines in Which Loading and Mixing of

Explosives were Conducted

Bldg	Room
220	All rooms except basement
218A	102, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 117, 121, 123. Delay powder loaded in basement under Room 105.
218B	110, 113, 115, 119, 123, 125, 127, 128-1, 128-2, 128-3, 128-4, 132
218C	104
219A	Loading of smokeless powder throughout

TABLE 4

Hanley Industries

Building Usage

Other than for Loading and Mixing of Explosives

Bldg	Area	Usage
218A	All rooms not listed on Table 3	Non-explosive storage
218B	Basement	Empty as non-explosive storage
218C	Basement	Burning of explosive contaminated rags
219D		Never used
219G		One time loading of explosives for disposal during cleanup operations
219C, B, F, J & H		Drying of explosives
219E		Lead azide production
All * other magazines		Storage of explosives in sealed containers
219A		Administrative

*Fencing arrangements in the 228 area reportedly precluded both beneficial and non-beneficial use of magazines 228A, B, C, D, G, N, O, and P by Hanley Industries. The Goodfellow US Army Reserve Center reportedly used these facilities intermittently for storage of equipment.

TABLE 5

Hanley Industries

Compounds Utilized

Lead Styphnate

Tetryl (2,4,6-Trinitrophenylmethylnitramine)

RDX

NOL 130 (Ignition mix)

A180 (Ignition mix)

Black Powder

HMX (Cyclotetramethylenetetranitramine)

NOL 60 (Ignition mix)

PETN (Pentaerythrite Tetranitrate)

Tetracene

Silver azide

Smokeless powder

Trinitroresorcinol

Diazodinitrophenol

Delay powder

Lead nitrate

Sodium azide

IV. SURVEY OVERVIEW.

A. Historical Study.

Because Hazardous/Chemical Area No. 2 was a portion of the former SLOP, it was necessary to determine if the property is contaminated with explosives or other hazardous materials prior to proceeding with actions to dispose of the property. As a first step in the program an historical investigation was conducted.

All available records were searched in an attempt to define the past operations which took place within the 27.88-acre area. This effort included searching the following document repositories: National Personnel Records Center, St. Louis, MO; Industrial Social Division of the National Archives, Washington, DC; Washington National Records Center, Suitland, MD; Offices of the Kansas City District Corps of Engineers, Kansas City, MO; and the Historical Office of the Army Armament Readiness Command, Rock Island, IL.

In a further attempt to gain information on the operations which took place at the site, old overhead imagery was obtained and studied. This information was obtained from EPA's Vint Hill Farms Station at Vint Hill Farms, Virginia.

Although a large amount of information was found, documents specific to building and magazine usage and decontamination were not located. Several documents which would have been useful had been destroyed (Appendix B, paragraph IV. B). Information on building usage and past decontamination efforts would have been extremely useful for: (a) tailoring the sampling and analysis efforts; (b) drawing conclusions about the status of residual contamination within the area with relatively little sampling and analysis data; and (c) allowing historical data and chemical analysis data to function as cross checks of each other.

Another means utilized to obtain information about past operations was personnel interviews with current and former employees. This technique produced some relevant information, however, the information could not be corroborated by other sources.

Over a 20 year period beginning in 1959, Hanley Industries, Inc., leased a 14.68 acre portion of Hazardous/Chemical area No. 2. During this period Hanley manufactured explosive devices. Hanley personnel were contacted to ascertain the building usage during their lease.

Results from this first step of the program produced some information on which buildings would likely be contaminated and with what materials. Although the archives search revealed that renovation and decontamination operations were conducted in the Hazardous/Chemical Area No. 2, there were no available documents which described the operations, or the level to which decontamination was actually achieved.

B. Survey Effort.

Historical information about Hazardous/Chemical Area No. 2 led to the development of a table of potential contaminants for which analyses would be conducted. The contaminants for the GUSARC area are shown as Table 6. The number of contaminants of concern was expanded for the Hanley Area survey to take into account operations occurring between 1959 and 1979 (Table 7).

Information provided by Hanley personnel led to the following conclusions:

1. Samples would have to be collected and analyzed for the potential contaminants listed on Table 7.

2. The areas of potential contamination tabulated on Table 8 would have to be sampled.

3. Heavy metal contamination was considered to be unlikely in most of the magazines in the Hanley Area as only a few of the magazines were used by Hanley and then only for the storage of explosive and supply items.

4. Hanley had never used the powder wells. The powder wells, unlike the other structures, did not have a 5X marking on them. Therefore, the powder wells in the Hanley Area were considered to have a high potential for containing explosive residues.

In order to select the locations for sampling, interior building configuration data were compared with the available historical information. Provided as Appendix C is a description of the various buildings and magazines which comprise Hazardous/Chemical Area No. 2.

Sampling and analysis for the GUSARC Area was performed under contract by Battelle Columbus Laboratories. The sampling effort was conducted in April 1979, and laboratory analysis in May 1979. Shortly thereafter the DOL representatives began renovating portions of the property.

Sampling and analysis of the Hanley Area was initiated August 1980. This was shortly after decontamination procedures were accomplished by Hanley personnel in compliance with lease termination requirements. Chemical analyses were performed in September and October 1980 with preliminary results of most analyses available in November 1980. The sampling and chemical analysis survey of the Hanley Area was also conducted under contract by Battelle Columbus Laboratories.

The survey program conducted at Hazardous/Chemical Area No. 2 utilized state-of-the-art detection methodology for explosives. This program included a cost effective mix of indicator sprays, thin layer chromatography (TLC) analyses and analyses of select samples by High Performance Liquid Chromatography. Sampling efforts focused on the areas most likely to contain contamination. The sampling and analysis efforts were designed to provide data which would form the

TABLE 6

Potential Contaminants

in the GUSARC Area, SLOP

2,4,6-Trinitroresorcinol (styphnic acid (TNR))

Cyclotrimethylenetrinitamine (RDX)

2,4,6-Trinitrotoluene (TNT)

Nitroglycerine (NG)

Pentaerythrite Tetranitrate (PETN)

Nitrocellulose (NC)

Lead Styphnate (PbSty)

Tetrazene (TETR)

Cadmiuim (Cd)

Chromium (Cr)

Lead (Pb)

Mercury (Hg)

TABLE 7

Potential Contaminants

in the Hanley Area, SLOP

2,4,6-Trinitrotoluene (TNT)

2,4- and 2,6-Dinitrotoluene (DNT)

2,4,6-Trinitrophenylmethylnitramine (Tetryl)

2,4,6-Trinitroresorcinol (Styphnic Acid)

Cyclotetramethylenetetranitramine (HMX)

Pentaerythrite Tetranitrate (PETN)

Lead Styphnate (Lead Salt of Styphnic Acid)

Tetrazene (TETR)

Nitroglycerine (NG)

Nitrocellulose (NC)

Lead (Pb)

Silver (Ag)

Nickel (Ni)

Mercury (Hg)

Chromium (Cr)

Cadmium (Cd)

TABLE 8

Areas of Poential Explosive Contamination

Hanley Area, SLOP

	Building/Magazine	Area
HIGH POTENTIAL	220	All rooms
	218	15 rooms
	218B	12 rooms
	218C	1 room and basement
	219A	All rooms
	219C, E, J, H	Throughout
	219G	Throughout
	227B, L, P, Q	Throughout
	226C, G	Throughout
	229M	Throughout
	Powder wells	Throughout
	Sewer lines	Throughout
MODERATE POTENTIAL	227O, N, M, K, J, H, G, F, E, D, C, A	Throughout
	226H, F, E, D, B, A	Throughout
	229L, N, H, J, K	Throughout
LOW POTENTIAL	227T	
	228 Series	
	Soil	
	Soils	
	Pipe Tunnels	
	Crawl Spaces	

basis for a conclusion about the presence of contaminants which would pose an explosives safety hazard. Indicator sprays were applied and swab samples were collected for TLC analysis where positive results were obtained from the indicator sprays. Swipe samples were used to check for the presence of heavy metal contamination on building interior surfaces. These samples were then taken to the laboratory for analyses by atomic Absorption Spectrometry.

The sampling of the Goodfellow US Army Reserve Center (13.2 acres) included sampling the interior surfaces of 41 buildings and seven bunkers for heavy metals and explosives. Spot sprays to detect the presence of explosives were extensively applied on and around floor drains and in cracks on floors and ceilings.

The sampling of the Hanley Area (14.68 acres) included the survey of seven buildings, 54 magazines and 28 powder wells. All buildings and magazines were checked for heavy metals and explosives on interior wall surfaces, in and around floor drains, and in cracks and drop ceilings. Powder wells and sewer lines were sampled and subjected to analyses for explosives and heavy metals.

In addition to sampling and analysis the survey included a visual inspection of the grounds, buildings and underground tunnels. During the visual inspection detonators were found behind magazine 219E (these were produced by Hanley, Inc.) in spite of the fact that Hanley personnel had already cleaned up the area. (These detonators were removed by Hanley personnel in August 1980.) Inspection of the buildings in the Hanley Area indicated that in several cases interior building walls were constructed of hollow tile in which explosives may have accumulated.

C. Evaluation of Data.

1. Explosives Contamination.

Results of the historical study and the sampling and analysis effort were used to infer the likelihood of an explosives contamination problem. Based on the historical survey of the GUSARC area it was believed that only a few buildings would have possibly been contaminated. Analytical data revealed that building interior surfaces were not contaminated.

In the Hanley Area, on the other hand, contamination was detected in several of the buildings and some of the magazines. The likelihood of contamination in this area was much higher because of operations conducted during World War II and subsequently by Hanley Industries. This area also contained powder wells which served as drainage sumps for the buildings. Certain powder wells showed trace levels of explosives in the standing water.

A third factor in the evaluation process was the configuration of structures themselves. Areas where explosives could accumulate in quantities posing a safety hazard are a concern. Building configurations were studied to determine if there were such areas. Places of likely accumulation were sampled. However, areas such as hollow tiles and drop ceilings could not be readily and safely sampled.

2. Heavy Metals.

Swipe samples were taken to obtain estimates of heavy metals levels on surfaces within a given building. The results of sampling and analysis surveys of the GUSARC and the Hanley Area showed that heavy metals (lead, mercury, silver, nickel, cadmium, chromiuim) were present on the building interior surfaces.

Based on levels measured on building interior walls inferences can be made as to the ingestion hazard. On this basis several of the buildings are not suitable for release due to lead contamination. With respect to occupational usage of the buildings, as is planned by DOL, the determination of a hazard depends on the future specific use of the buildings because the potential hazard is a function of the building use and the amount of material which will become airborne as a result of that use. Air monitoring during renovation and occupancy would be necessary to assure compliance with OSHA limits. Air monitoring of vacant structures as part of the survey program was judged not to be of sufficient value over swipe sampling to warrant the additional expenditure of funds.

D. Data Management.

Data collected in the field, i.e., sampling location, type of indicator spray applied, were logged on field data sheets. This information was transferred onto USATHAMA sampling and analysis forms, merged with laboratory analysis result data, validated by the contractor and submitted to USATHAMA. This data was reviewed and validated by USATHAMA and entered into the USATHAMA Data Management System where it was keyed to a computerized map of the Hanley Area.

E. Actions Interim to Study Completion.

1. Statement for Use of GUSARC.

The DOL requested that the GUSARC Area be made available as soon as possible and that separate certifications be provided for each area; the GUSARC area first, with the Hanley area certification provided shortly thereafter.

In June 1979 USATHAMA prepared a Statement for Use of the GUSARC Area. As heavy metal and exposive contamination was found to be present in the GUSARC area, a meeting was held with representatives of the DOL, Leo Daly Company (DOL A/E contractor), the US Army Environmental Hygiene Agency and USATHAMA later that month to discuss the Statement for Use and the survey results. Levels of explosives in the floor drains were not considered to pose a sufficient hazard to preclude all renovation efforts. It was suggested that the DOL take the following actions regarding the heavy metal contamination.

a. Conduct air monitoring for heavy metals to assure compliance with OSHA standards.

b. Sample the liquid discharge from the sewer system to assure compliance with the discharge standards of the city of St. Louis.

2. <u>DOL Access to Hanley Area Prior to Survey Conclusion.</u>

An onsite meeting was held in June 1980 with representatives of DOL, the Kansas City District Corps of Engineers Real Estate Division, the Post Engineer for the St. Louis Area Army Reserve, Hanley Industries and USATHAMA attending. This meeting was held to (a) conduct a visual inspection of the Hanley Area prior to the finalization of the scope of work for the USATHAMA survey of the area; (b) arrange for DOL access to the Hanley Area via the bridge over Goodfellow Boulevard (Fig. 5); and (c) determine the acceptability of the gas line route which was proposed by the DOL.

During June 1980, USATHAMA responded favorably to DOL's request to route the gas line as shown on Fig. 5 and concurred in DOL's use of the access bridge over Goodfellow Boulevard provided that a security fence was installed so as to totally fence off the potentially contaminated area bordering the road between the access bridge and the former GUSARC Area.

3. <u>Interim Status Report on the Hanley Area</u>. At the request of DOL, USATHAMA prepared an interim status report for the Hanley Area based on the preliminary results obtained from the survey conducted August-October 1980. The status report, submitted to the US Army Materiel Development and Readiness Command Headquarters indicated the following:

a. Explosive residues were present in a few powder wells and in some buildings (on walls, floors, window sills).

b. Heavy metal residues are present in sewer lines and on all building interior surfaces.

TABLE 9

Summary of GUSARC

Sampling Program

Building	Swipes	Physical Samples	Sprays	Swabs	Sumps
234	21	13	30	3	3
234 (A)	22	19	43	2	3
223 (B)	11	13	16		3
222 (A)	9	8	11		
244	3	1	6		
231 (series)	6	21	24		
243 (series)	9	24	24		
232 (series)	9	8	16		
Underground bunkers	-	-	7		
224	-	-	-		1
TOTAL (389)	90	107	177	5	10

D. Survey Results

1. Heavy Metal Contamination

a. Heavy metal residues were found in the walls of the following buildings/bunkers (Fig. 6):

22A	231N	232F	243D
223A	231P	232G	243E
223B	232A	232H	243F
231A	232B	234	243G
231C	232C	243A	243H
231E	232D	243B	244
231G	232E	243C	

b. Heavy metal concentrations were reported in units of micrograms per square meter (ug/m^2) and concentrations ranged as follows:

Cadmium: 0.99 ug/m^2 - 4422 ug/m^2

Chromium: 2.20 g/m^2 - 5562 ug/m^2

Lead: 1.10 ug/m^2 - 36,440 ug/m^2

Mercury: 0.23 ug/m^2 - 44.80 ug/m^2

These results are tabulated in Appendix D.

2. Explosive Contamination. PETN and NG residues were found in the floor drains of buildings 232A, 232C, 232E, and 232G (Fig. 7). The levels of PETN and NG were estimated to be at or near the detection limit of the TLC analyses (50-75 ug/g).

VI. HANLEY AREA SURVEY SAMPLING AND ANALYSES.

A. General. Seven buildings, 54 magazines, 28 powder wells and five sewer locations were sampled for heavy metal and explosive residues. The compounds of interest are listed on Table 7. One-half of all samples were stored by the contractor pending the conclusion of the survey in case it was necessary to analyze the discrete samples (comprising the composite samples), separately. No further analyses were conducted on the stored samples.

B. Heavy Metals.

1. Swipe Samples. At least four surface areas in each of the buildings/magazines were wiped with Whatman No. 541 filter paper, pre-wet with a distilled water/detergent solution. One square meter of surface area was wiped on the floors/walls in selected rooms. Specific sampling sites were based on the past usage of specific rooms. In general, swipes were taken from a section of floor, baseboard, and wall. Swipes were placed in sealed bags and returned to the laboratory for compositing and analysis by atomic absorption spectroscopy for lead, silver, nickel, mercury, chromium, and cadmium.

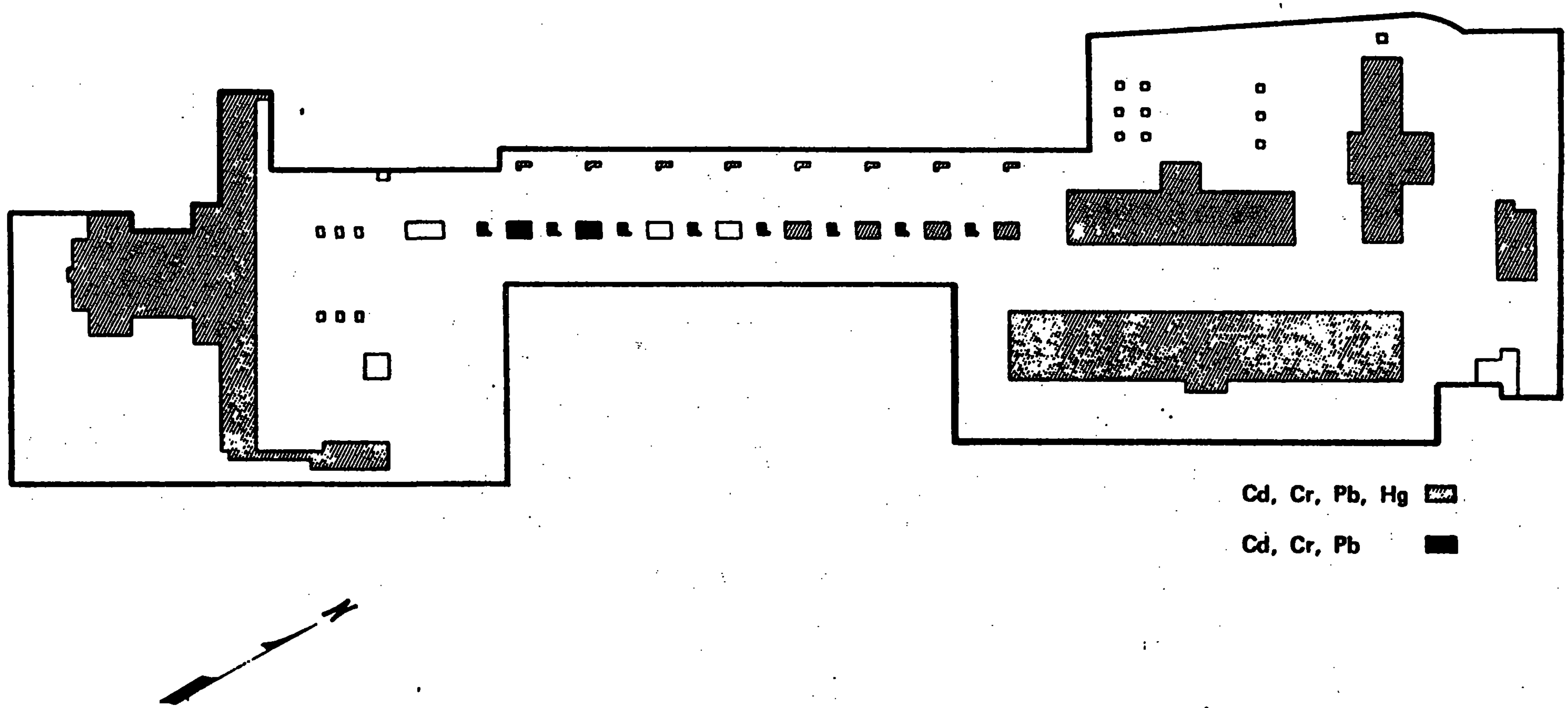

Figure 6. GUSARC Facilities contaminated with heavy metal residues.

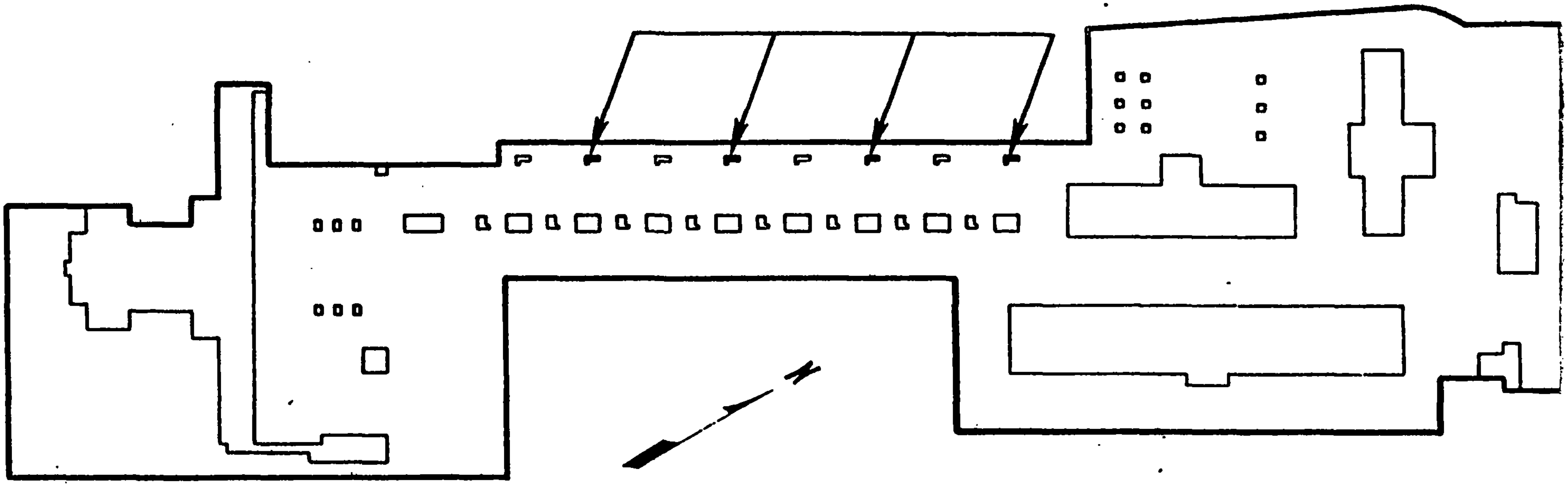

Figure 7. GUSARC Magazines in which floor drains were found to contain explosive residues.

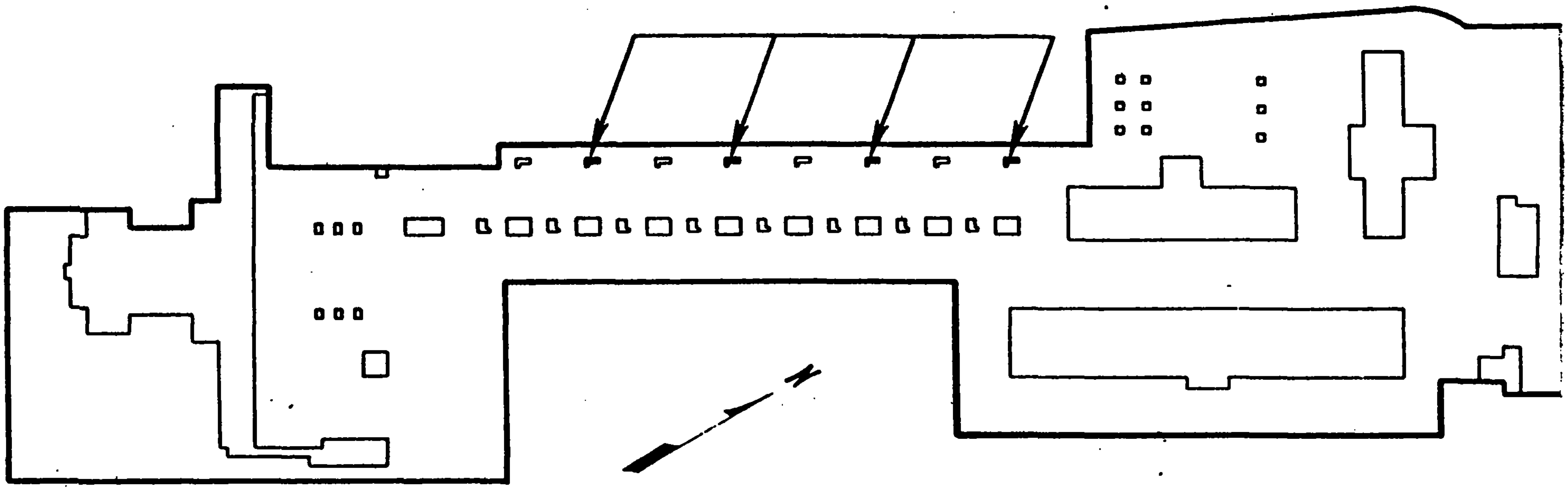

Figure 7. GUSARC Magazines in which floor drains were found to contain explosive residues.

2. Physical Samples. Water samples were collected from five sewer locations. These locations were sewers which drained powder wells, buildings, and magazines in both the GUSARC and Hanley Areas. All samples were placed in pre-washed 500 ml brown glass bottles, labeled, and returned to the laboratory for analysis.

C. Explosives.

1. Spot Sprays.

Five different indicator sprays were used in each room to detect five different explosive classes. Appendix D provides a full listing of spot spray results as well as delineation of which explosives can be detected with each of the five spot spray reagents. The spot spray methodology is described fully in Appendix F.

Spray locations included walls, drains, vents, pipes, window sills, ceiling fixtures, machinery, shelves, stalactites, and floors. Subsequent to the spray application, each location was outlined with a waterproof indelible marker. These areas were numbered (with the spot spray number) and recorded on the data sheets along with the spray results. Over 900 spot sprays were applied. Each room had five locations for spot spray application preselected. Only one spot spray was applied to each location.

Spot spraying was continued in each room of each building (magazines are one-room buildings) until either all five sprays showed negative results at all the locations selected for testing or until a positive response was obtained to one of the spray reagents. Upon obtainment of a positive, a swab sample was collected for the purpose of laboratory analysis to confirm the positive.

The responsiveness of each spray was checked at least once each day by spraying swabs which had been dipped into a 0.012 percent solution of the respective compound. The sprayed swab was observed for the appropriate color change. This procedure constituted an analysis of standard samples.

2. Swabs. Swab samples were collected near each location where positive results were obtained with the indicator sprays. Cotton tipped swabs diped in acetone were used to collect these samples. The swabs were placed in vials for subsequent compositing by magazine group or individual building and laboratory analysis by TLC and HPLC for all explosives listed on Table 7.

3. Physical Samples. A one liter water sample was collected from each of 28 powder wells. The sample was collected by submerging pre-washed, brown glass containers below the surface and allowing the water to fill the bottles. Containers were capped, cooled, and returned to the laboratory for analysis. Water samples were also collected from five sewer locations.

D. Survey Results.

1. Heavy Metal Contamination.

Swipe samples for heavy metal analyses were composited by building number and magazine group and are reported as micrograms per square meter (ug/m^2). Heavy metal concentrations ranged from below detectable limits to 24, 147, 32, and 102 ug/m^2 for silver, nickel, mercury, and cadmium, respectively. Lead and chromium were found at concentrations above detectable limits in all of the buildings (Fig. 8) surveyed. Concentrations of chromium ranged from 26 to 515 ug/m^2. Lead concentrations ranged from 800 to 27,200 ug/m^2. Magazine 219E which housed Hanley's lead azide reactor (and which was the only building in which the glazed tiles had been painted) had the highest lead concentration. The average lead concentration for buildings in the Hanley Area was found to be slightly less than 6,000 ug/m^2. An analytical method for lead azide is not available and therefore lead concentrations must be used to infer the possible presence of lead azide.

Concentrations of silver, mercury, and chromium were below detectable limits in all sewer samples. Lead concentrations ranged from below detectable limits to 230 ppb. Nickel concentrations ranged from below detectable limits to 115 ppb.

2. Explosive Contamination.

Indicator spot sprays are capable of detecting the presence of explosives nitrite based substances above the level of 0.4 ug/m^2. Positive spot spray results were obtained in buildings 218A, 218B, 218C, 219A, 219D, 219G, and 220. Positive spot spray results were also obtained in the following magazines:

219E	227B	228F	228Y
219F	227J	228G	229K
219H	227M	228N	229N
219J	227O	228P	
227A	228C	228W	

Physical samples (swabs) to check for false positives were collected from all rooms in all buildings and magazines which exhibited a positive spot spray result. These physical samples were composited by building number and by magazine group for additional analysis using thin layer chromatography (TLC) to differentiate between positive responses due to the presence of interfering materials and positive responses due to the presence of explosives.

High Performance Liquid Chromatography (HPLC) was used to quantify HMX, as TLC was ineffective in identifying this compound. The sensitivity of the HPLC method is three orders of magnitude greater than the sensitivity of the TLC method. Therefore, HMX was detected in extremely minute quantities (0.008 - 0.03 ug/cm^2) as in the following magazines: 219C, 219H, 227A, 227B, 227O, 228C, and 228F.

TLC and HPLC analyses confirmed the presence of explosives in buildings 218A, 218B, 218C, and 220. TLC and HPLC analyses also confirmed the presence of explosive contamination in magazines 219C, 219H, 227J, 227M, 227O, 228C and 228F. Negative results were obtained for the 226 and 229 magazine series.

The shaded areas shown on Figure 9 indicate the first floor rooms in which explosive residues were detected. The composite sample taken in the stair well leading to the basement of building 218C showed a positive result for PETN and HMX.

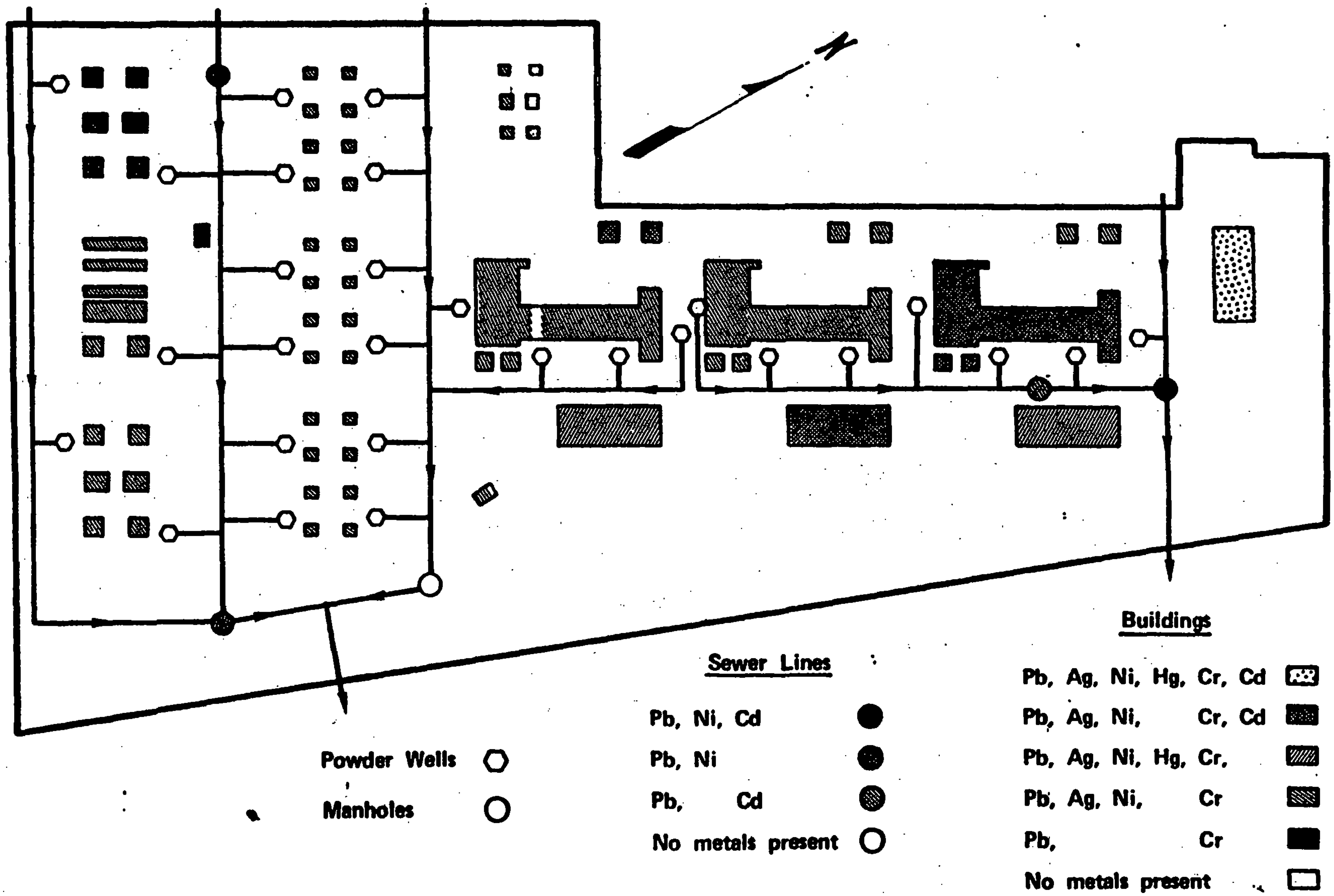

Figure 8. Hanley Area facilities contaminated with heavy metal residues.

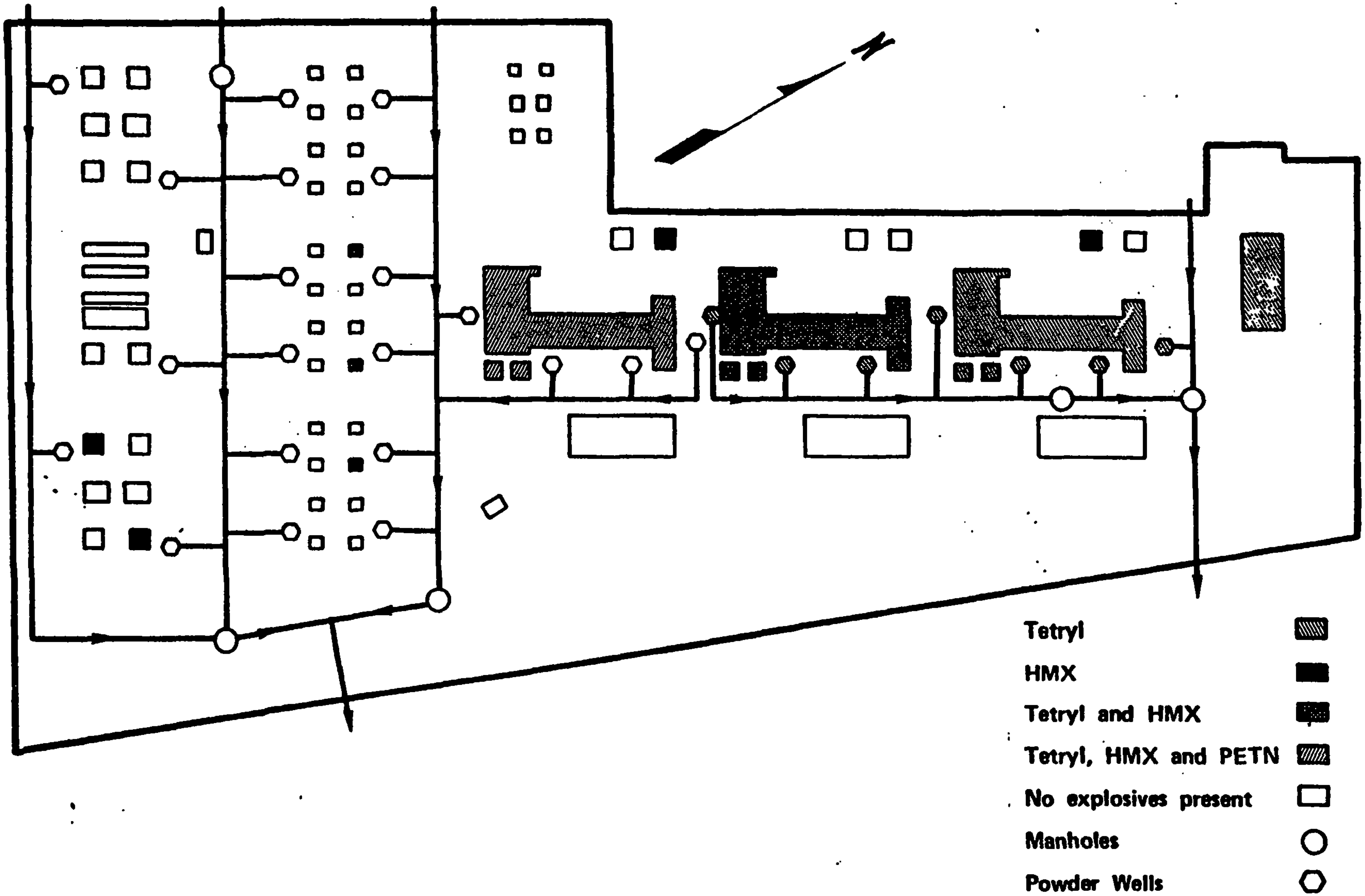

Figure 9. Hanley Area facilities contaminated with explosive residues.

Water samples from the powder wells were composited into nine samples by building or magazine group (maximum of four samples per composite). Explosive compounds were not found in any of the powder well samples above detectable limits except in those samples collected from the powder wells which received effluent from buildings 218A and 218B. The composite samples from these powder wells contained 4.0 and 4.6 ppb of tetryl, respectively.

None of the sewer samples contained explosive compounds in concentrations above the detection limit of the method of analysis.

VII. CONCLUSIONS.

A. General. Compositing of samples by individual building in those cases where the buildings contain many rooms or by magazine group was accomplished. Analyses were largely qualitative in nature. Such an approach was necessitated by the lack of historical information on the nature of the installation operations and decontamination by the need to conduct a cost effective survey. Therefore, conclusions, for the most part, are drawn concerning the status of contamination of entire buildings and groups of magazines. Conclusions concerning specific facilities are presented only where quantitative analytical methods were performed on discrete samples.

B. Goodfellow US Army Reserve Center

1. Heavy Metal Residues. As tabulated on Table 10 and shown on Fig. 6, heavy metal residues are present on the walls of 27 buildings and magazines. Due to the lack of information concerning the historical use of buildings, correlation between building usage and survey results is not possible. The concentrations of metals found on the interior building/magazine surfaces are not considered a problem. However, should these residues become airborne, an inhalation hazard could result.

2. Explosive Residues. All buildings, magazines and sumps were found to be free of explosive contamination except for magazines 232A, 232C, 232E, and 232G. The floor drains in these four magazines were found to contain explosive residues. A correlation between past usage and survey results is not possible due to the lack of information concerning the historical use of these magazines. The levels of explosives are far below the concentrations required to present an explosive hazard.

C. The Hanley Area.

1. Heavy Metal Residues.

As tabulated in Table 11 and shown on Fig. 8, heavy metal residues were found on all building and magazine interior surfaces and in the discharge of the sewers. As most of the Hanley Area had been used for primer and tracer mixing (operations involving the use of metal based compounds) these results coincide with the historical building usage. The highest level of all heavy metals analyzed for in the survey was found in magazine 219E. This can be explained by the fact that the glazed tile had been painted or by the fact that the Hanley Industries lead azide reactor was operated in this magazine.

TABLE 10

Goodfellow US Army Reserve Center

Survey Findings

Building/Magazine	Findings
223A & B	Interview: Tracer Bullet Manufacturing. Survey: Heavy metal residues present on building surfaces.
234	Interview: Primer manufacturing. Survey: Heavy metal residues present on building surfaces.
232A, C, E & G	Records & Interviews: Use unknown. Survey: Explosive residues present in floor drains; heavy metal residues present on building surfaces
224A, B, & C	Records & Interviews: Use unknown.
225A, B, C, D, E, and F; 230; 236F; 237B 231J & L; 233A, B, C, D, E, and F	Survey: No heavy metal or explosive residues present
244; 222A;	Records and Interviews: Use unknown
232B, D, F, and H; 231A, C, E, G, N, and P; 243A, B, C, D, E, F, G, and H	Survey: Heavy metal residues present on building surfaces

NOTE: Building specific decontamination information is not available. However, there is a record that buildings having explosive hazards were decontaminated in 1945.

TABLE 11

Hanley Area

Survey Findings[1]

Buildings/Magazine	Findings
220	Records and Interviews: (a) Used for administrative space (1941-1945); (b) Explosive laboratory (1959-1979). Survey: Explosive and heavy metal residues present.
218A, B and C	Records and Interviews: (a) Primers and tracer mixing (1941-1945); (b) Loading and mixing of explosives (1959-1979). Survey: Explosive and heavy metal residues present in buildings. Explosive residues present in powder wells draining 218A and B.
219A, D and G	Records and Interviews: (a) Primer and tracer mixing (1941-1945); (b) Loading of smokeless powder (219A) and administrative space (219D and G) from 1959-1979. Survey: Heavy metal residues present.
236	Records and Interviews: (a) Appears to be a garage 1941-1945; (b) 1945-1979 not used. Survey: Heavy metal residues present.
219C and H	Records and Interviews: (a) 1941-1945 use unknown; (b) Open air drying of explosives (1959-1979). Survey: Explosive and heavy metal residues present.
219E	Records and Interviews: (a) 1941-1945 use unknown; (b) Lead azide production (1959-1979). Survey: Heavy metal residues present.
219B, F, and J	Records and Interviews: (a) Open air drying of explosives (219B) and burning (in 219F and J) of explosives (1959-1979). Survey: Heavy metal residues present.
229 Series	Records and Interviews: (a) 1941-1945 use unknown. (b) Storage of explosive end items (1959-1979) Survey: Heavy metal residues present.
226 Series	Records and Interviews: (a) Explosive mixing operations (1941-1945); (b) Storage of explosives in sealed containers (1959-1979). Survey: Heavy metal residues present.

Table 11 (Continued)

Buildings/Magazine	Findings
227 Series	Records and Interviews: (a) Explosive mixing operations (1941-1945); (b) Storage of explosives in sealed containers (1959-1979). Survey: Heavy metal residues present in all magazines. Explosive residues present in 227A, 227B, 227J, 227M and 227O.
227T	Records and Interviews: (a) Administrative space (1941-1945); (b) Abandoned 1945-1979. Survey: Heavy metal residues present.
228 Series[2]	Records and Interviews: (a) Powder storage (1941-1945); (b) Abandoned from 1945-1979. Survey: Heavy metal residues present in all magazines. Explosive residues present in 228C and 228F.

[1]NOTE: Building specific decontamination information is not available. However, there is a record that buildings having explosive hazards were decontaminated in 1945. The buildings and magazines in the entire Hanley Area were marked "XXXXX" which indicates that the structures had been inspected after decontamination and were considered safe, and that no explosives remained in the structures.

[2]Magazines 228A, B, C, D, G. N, O, and P were reportedly used by the GUSARC for intermittent storage of equipment. Hanley Industries reportedly did not have access to these magazines.

2. Explosive Residues.

a. Explosives - General.

Explosive residues were found on the walls in buildings (218A, 218B, 218C and 220) and magazines (219C, 219H, 227J, 227M, 227O, 228C, 228F), as well as in the standing water present in the powder wells draining buildings 218A and 218B. No explosives were detected in the discharge of the sewer system.

b. 218 Buildings. The presence of explosive residues in 218A, 218B, and 218C coincides with the explosive loading, mixing and disposal operations which were conducted in these buildings from 1941 to 1979. The presence of tetryl in buildings 218A and 218B as well as in the powder wells connected to these buildings leads to the conclusion that the drain lines from these buildings to the powder wells also contain tetryl. The presence of drop ceilings, wooden roofs, and hollow tiles raise the concern that residues may have accumulated on top of the ceilings and within the walls.

c. Building 220. The presence of explosive residues in this building is understandable as this was Hanley's explosive laboratory. It is assumed that the drains in this building were used for disposing of small quantities of explosives. Building 220 has a cement ceiling which would keep any explosive residues from entering the top of the wall and sifting down through and accumulating in the hollow tiles.

d. Magazines 227E, F, G, H, J, K, L, and M.

The results of the analyses on physical samples collected from magazines 227J and 227M show explosive contamination (HMX and Tetryl) to be present at significant levels. As these two magazines are indicative of the contamination present in the group of magazines, the group is considered to contain the same level of contamination. The level found was commensurate with the levels of contamination found in buildings 218A, 218B, 218C and 220.

All of the magazines have drop ceilings and are constructed of wood. It is concluded that these magazines have a high potential to contain explosive residues in the the walls and above the ceilings.

e. Magazines 219C, 219H, 227O, 228C, and 228F.

These magazines were found to contain trace amounts of HMX in residues sampled from the magazine interiors. The levels were at least two orders of magnitude lower than the levels found in other buildings and magazines (227E, F, G, H, J, K, L, and M). It is concluded that these levels are not sufficient to pose an explosion hazard but that low levels of explosives could be present. It is further concluded that these levels are indicative of the trace levels of contamination which may be present in all of the magazines in the Hanley Area.

f. Powder Wells.

Tetryl was found only in the water in the seven powder wells draining buildings 218A and 218B. The sludge in the powder wells could not be analyzed for explosives as a suitable analytical method is not available. Due to the presence of sludge in each of the 28 powder wells it is concluded that explosive residues may be present in the sludge in each powder well.

VIII. Recommendations

A. Goodfellow US Army Reserve Center Area

1. Heavy Metal Contamination. Since there were no standards for the heavy metal contamination found at the GUSARC, it was recommended that the DOL:

a. Conduct air monitoring for heavy metals to assure compliance with OSHA standards; and

b. Sample the liquid discharge from the sewer system to assure compliance with the discharge standards of the city of St. Louis.

2. Magazines 232A, 232C, 232E and 232G. In regard to the explosive residues found in the floor drains of magazines 232A, 232C, 232E, and 232G the following recommendations were provided:

a. The floor drains should be scraped of all residue prior to connecting the gutters to the floor drains.

b. Floor drains which will not be used should be cleaned (to ensure that no large accumulations of explosives are present) and then filled with concrete.

c. Pipes should not be welded onto existing pipes, rather, molten lead packing should be used.

d. Flame producing machinery associated with the renovation operations should be operated outside of the magazines.

B. Hanley Area.

1. Heavy Metal Contamination. As the buildings and magazines in the Hanley Area will be demolished, the levels of heavy metals found on the building/magazine surfaces should pose no problem. Air monitoring or the use of respirators during rip-out operations is recommended. The liquid discharge from the sewer system should be sampled to assure compliance with the discharge standards of the city of St. Louis.

2. Buildings 218A, 218B, 218C, and 220. These buildings should be flashed (consideration could be given to the possibility of chemically neutralizing building 220, however, flashing is the recommended decontamination procedure). In order to avoid hazards associated with airborne asbestos, all

asbestos materials must be removed prior to burning. The drain lines leading to the powder wells draining buildings 218A and 218B should be removed and flashed. The drain lines from building 220 to the sewer main should also be removed and flashed.

3. Magazines 227E, F, G, H, J, K, L, and M. The magazines in this group should be flashed prior to demolition. All asbestos materials must be removed prior to burning to avoid generating an asbestos inhalation hazard.

4. Remainder of Hanley Area.

a. Renovation and demolition operations involving all other magazines and buildings in the Hanley Area should be conducted without the use of spark or flame producing machinery. All work in the Hanley Area should be carried out under the guidance of a safety officer and with the understanding that undetected levels of explosives may exist.

b. All drain lines should be cleaned and filled with concrete.

c. Access to the Hanley Area should be controlled until all decontamination/demolition work is completed.

C. General. The following recommendations are applicable to both the Goodfellow US Army Reserve Center Area and the Hanley Area.

1. All work in these areas should be overseen by persons knowledgeable of the contamination.

2. Personnel involved in decontamination activities should not work alone.

3. A complete record of all decontamination actions should be maintained in order to verify the adequacy of the decontamination. This record should include numbers and names of demolition techniques employed.

4. Flame producing devices should not be used before decontamination.

5. Standard operating procedures (SOP's) should be prepared for all operations conducted in the contaminated portions of SLOP. An example of such an SOP is found at Appendix G.

6. All powder wells and sumps containing sludge should be drained of their contents and the sumps and wells should be flashed.

7. Flashing entails subjecting the potentially contaminated surface to a hot fire in order to destroy the explosive material. In the case of the buildings, magazines, drain lines, sumps, powder wells, and sludges from the powder wells at SLOP for which flashing is recommended, "flashing" can only be achieved by total burning. (It is noted that solvents and steam cleaning are considered effective decontamination procedures only when complete inspection can be given to all surfaces to assume decontamination has occurred).

8. Should open burning of buildings and magazines pose a problem because of the location of SLOP, a technique which has been used successfully is a charcoal fire. This technique produces a high temperature, controlled burn with far less smoke and flame.

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